7-October-2020

Public Testimony: Willow Ridge Geologic and Hydrologic Risk Parameters

Willow Ridge Proposed Development
4096 Cornwall St., West Linn, OR
Tax Lot: 6300

This document provides an assessment of geologic and hydrologic risk related to the proposed Icon Construction and Development (ICON) project on Tax Lot 6300 (Willow Ridge Development). The testimony provided herein was produced by William House on a pro gratis basis for the residents of various communities surrounding the proposed Willow Ridge development. The testimony provides an assessment of available technical data to determine geological and hydrological risk parameters associated with the development and assess risk mitigation plans.

This document does not provide the following:

1) A technical basis for the design of any physical structures.
2) An exhaustive assessment of local geologic and hydrologic conditions

Interpretations of data provided in this document represent the informed opinion of William House based on the resources cited under Data Sources.

William House is a retired professional geologist with an academic background that includes an MS Degree in Geology and a BA Degree in Environmental Sciences. He has extensive experience in subsurface geology from working as an exploration geologist in the petroleum industry for 34 years. He currently resides at 3483 Cascade Terrace, West Linn, OR.

Executive Summary

A geological and hydrological risk assessment of the Willow Ridge Development was undertaken at the request of local residents. The assessment was based on publicly available data.

The two key findings of the study are:

1. The ICON application does not recognize the presence of a perched water table outcropping on the Willow Ridge slope at approximately 460 feet above sea level (ASL). Flooding and slope stability risks associated with this geological feature are not addressed in the Willow Ridge Development application (Exhibit 7).
2. Geological risk from shallow landslides is discussed in the application, but these discussions do not include an analysis of how groundwater flow from the perched water table may affect slope stability, nor do they specifically address slope instability issues related to the excavation of slope-toe materials along the perched water table (Exhibit 10).

Hydrologic Risk:

Available geological mapping in the area indicates that the rocks below ground level consist of flat tabular basalts associated with two units of Frenchman Springs member of the Wanapum Basalts. The geological formation contact between these two units is interpreted to occur at approximately 460 feet above sea level, based on well data and offset geological mapping (Geologic map of the Oregon City 7.5' quadrangle, Clackamas County, Oregon, by Ian P. Madin, 2009 – Exhibit 1). The formation contact is important because hydrologic systems in basalts are heavily influenced by contacts between basalt flow units.

Subsurface descriptions support this interpretation based on the well log from the Clackamas County water well CLAC 69447 drilled on the property with an address of 4197 Reed St., West Linn, OR (approximately 123 feet from the north corner of the Willow Ridge plot – Exhibits 2 & 3). This well identifies a perched water zone between 462 feet and 481 feet ASL (Exhibit 5). The base of the perched water zone is consistent with the projected formation contact. This perched water zone outcrops on the Willow Ridge slope and appears to feed springs along that slope (Exhibits 6, 7, & 7a).

Ground disturbance from construction or increased ground water percolation above an elevation of 460 feet ASL will affect the perched water zone and may result in either increased flow from existing springs or the formation of new springs. These changes in groundwater flow may pose increased flooding risk to the properties at the base of the Willow Ridge slope and may also create slope stability issues.

A history of flooding on these properties has been previously noted in past public testimony. Both flooding of backyards with surface waters and flooding of crawl spaces with ground water

seepage have been noted. Construction along the water table discharge zone needs to mitigate risk for both surface runoff and flow from the existing ground water drainage system where it outcrops on the Willow Ridge slope.

The letter from GeoPacific dated December 18, 2019 states that "*No groundwater was encountered in any of the test pits.*" This is inconsistent with the 2016 Carlson Geotechnical report showing groundwater seepage in three of the seven test pits (TP-4, TP-5, & TP-6). Two of these pits (TP-5 & TP-6) are located on the SW lower slope below the perched water table outcrop, and they experienced ground water seepage at about 4 feet BGS, demonstrating lower slope water flow in the soils. This is interpreted to be part of the groundwater drainage from the perched water table. Plans to mitigate crawl space flooding risk from changes in the groundwater drainage system on the Willow Ridge property are not address in the application.

(Note: The GeoPacific Letter also referenced geotechnical work from December 10, 2019. This work could not be located and the reference is assumed to be for the December 10, 2015 work done by Carlson Geotechnical)

Previous public testimony from Stonegate residents has demonstrated the relationship between drainage changes due to upslope construction and increased water flow from the perched water zone (2017 testimony by Chelsea Diaz). The perched water table outcrops behind the Diaz home, and flooding problems from that zone coincided with upslope construction (Exhibit 8).

Landslide Risk:

The eastern half of the Willow Ridge Development plot is shown on Oregon State Department of Geology and Mineral Industries Shallow Landslide maps as having a moderate to high susceptibility to shallow landslides (Exhibit 9). Any construction activities resulting in increased soil water content or removal of slope-toe materials will increase this risk.

Two types of shallow landslide risk are identified:

1. Shallow rockslide risk on the steep slopes between 467 and 480 feet ASL. This risk will increase if construction either removes the materials at the base of this slope or causes increased ground water flowage from the existing seeps between 460 and 467 feet ASL (Exhibit 10).
2. The risk of mud flows or rotational soil slumps on the lower slopes will increase if construction results in increased ground water seepage on the Willow Ridge slopes.

The Willow Ridge property contains geologic and hydrologic conditions not usually encountered with residential construction in this area. The fact that a perched water table outcrops on this slope is not addressed in the application. The groundwater hydrology of this property is particularly important since homes are planned for construction along this perched water table. Construction may also increase the risk of groundwater related flooding and slope instability unless engineering solutions are designed and implemented to mitigate these risks.

Data Sources:

A full description of the proposed development is provided in the ICON January 7, 2020 Development Review Application, received January 13, 2020 by the City of West Linn. This application was used as a source of technical information regarding geotechnical and hydrological investigations carried out in support of ICON's proposed development.

Additional sources of data include:

1) Clackamas County water well CLAC 69447 drilled on the property with an address of 4197 Reed St., West Linn, OR.(Reed Street Well)

2) Geologic map of the Oregon City 7.5' quadrangle, Clackamas County, Oregon, by Ian P. Madin, 2009

3) Statewide Landslide Information Database for Oregon (SLIDO): earthquake and landslide maps

4) Shallow-Landslide Susceptibility Map of the Northeast Quarter of the Canby Quadrangle, Clackamas County, Oregon; 2013; OPEN-FILE REPORT O-13-08 – Plate 45

5) City of West Linn GIS resources in the online MapOptix tool

6) Public testimony from previous hearings

Local Geology

The shallow subsurface geology of the area consists of Columbia River Basalts. These rocks include basaltic magma flows originating in Eastern Oregon or Idaho and deposited as tabular sheets in the West Linn area about 15.5 million year ago. The Frenchman Springs member of the Wanapum Basalts is interpreted to be present in the Willow Ridge Development project area based on projecting the mapped geology of the Oregon City Quadrangle. The eastern corner of the Willow Ridge property is located approximately 1570 feet from the edge of the mapped areas of the Oregon City Quadrangle geologic map (Exhibit 1).

The Frenchman Springs member is divided into the upper Sandy Hollow Unit (Twfs) and the lower Gingko Unit (Twfg) (Exhibit 1a). The contact between this units occurs at 460' ASL on the western edge of the Oregon City Quadrangle geological map. The tabular nature of these units allows a reasonable interpretation that the contact will be at the same level 1,570 feet to the west of the geologic map in the Willow Ridge development (Exhibit 1).

Well Data

Clackamas County water well CLAC 69447 drilled on the property with an address of 4197 Reed St., West Linn, OR.(Reed Street Well). The Reed Street Well log report was retrieved from the Oregon Water Resources Department's public domain files (Exhibit 2). The well was reviewed to understand the subsurface geology in the vicinity of the Willow Ridge Development. The well is located approximately 123 feet from the north corner of the Willow Ridge Development property (Exhibit 3). The well was drilled in 2013, reached a total depth of 422 feet below ground level (BGL), and it was completed at a depth of 388 feet BGS. The top 100-foot section of the well is relevant to the Willow Ridge Development analysis.

The well elevation at ground surface is estimated at 508 feet ASL (Exhibit 4). The well initially drilled 27 feet of clay and weathered basalt. This was followed by a 13 foot zone of loose gray and brown basalt and 6 foot zone of multi-colored basalt. These two zones, from 27 feet to 46 feet BGL, form a 19 foot flowable, water-bearing interval (Exhibit 5). The well was projected onto the West Linn City MapOptix terrain map at a surface level of 508 feet ASL (Exhibit 4). The terrain map uses contour data from a 2014 survey.

The base of the water-bearing zone is 462 feet ASL. This correspond closely with the projected geological contact between the upper and lower Frenchman Springs units Below this contact gray basalts followed by gray/brown fractured basalts were encountered. The next water zone in the well was encountered between 216 – 280 feet ASL.

Well Data Interpretation

Observations from the water well demonstrate the existence of a perched water layer between approximately 460 feet asl and 480 feet ASL. The term perched refers to an aquifer that is located above a deeper primary water bearing formation. Given the tabular nature of the basalt layers, this water would be expected to exit to the surface in locations where the topography cuts lower than the water zone.

The steep slopes of the Willow Ridge Development represent an area where the topography cuts through the Frenchman Springs basalts and exposes the perched water unit to the surface. The water zone cuts across the development area in a generally NW-SE line, following the topography between 460 – 480 feet asl (Exhibit 6).

The water zone map in Exhibit 6 was constructed using the MapOptix contours. The exhibit denotes differences between the MapOptix 460 foot contour and the ICON maps used in their original planning application.

A cross sectional representation of the local geology and the perched water zone is shown in Exhibits 7 & 7a. The diagram shows the natural water flow from the subsurface to the surface

along the Willow Ridge slope. The zone of flow corresponds to the noted presence of live springs and water loving Willow trees that occur naturally along the length of the ridge.

The dynamics of this natural water flow system are such that water enters the system via precipitation on the ground surfaces above the 460 foot contour. The water migrates vertically into the soils until it reaches the top of the gray basalt layer at about 460 feet ASL. This layer forms a permeability barrier and the water accumulates as a perched aquifer. The free surface along the Willow Ridge slope provides and exit point for the water and allows the aquifer to drain (Exhibit 7).

Water Flow in Basalts

Subsurface water movement can occur in two types of systems:

- Pore system networks: These types of networks rely on rocks like sandstones that are composed of many individual rock grains or fragments. The space between grains is referred to as pore space, and water can move through this pore space

- Fracture system networks: In rocks that have no intergranular porosity water must move through fractures in the rocks. Basalts are generally considered to be fracture network flow systems.

The distinction between these two types of systems is important because pore system networks will more evenly distribute water flow throughout the rock unit and are thus more predictable. Fracture system networks rely on fracture distribution patterns, which can be unpredictable. Fracture system networks have the capacity to concentrate flow into a limited number of conduits.

The practical difference between the two types of systems can be envisioned by considering the discharge of 100 gallons of water over an hour period through both types of systems, each with 100 square feet of slope exposure. Over the 1 hour period, one gallon of water would discharge from each square foot of the pore network system. If we assume 2 exposed fractures in the fracture network system, then over the hour period 50 gallons of water would discharge from each fracture. Fracture systems concentrate flow.

This distinction is important in the Willow Ridge area since the perched water aquifer is in basalts. The expectation is that flow will be concentrated in local areas and increased water flow into the aquifer, or disruption from construction will result in either increased flow from existing springs or the formation of new springs.

Observational Support for the Proposed Hydrologic System

Previous testimony regarding the Willow Ridge Development has pointed out the flooding problems currently experienced by the residents with properties on the SW edged of the development plot. The natural subsurface flow of water creates a series of springs on the slopes of the Willow Ridge Development. Surface development of the area will change the existing surface and subsurface water flow patterns.

Public testimony in 2017 by Chelsea Diaz demonstrated a clear connection between upslope changes in drainage cause by construction and the subsequent increased water flow from the same geological formations that occupy the Willow Ridge Development slopes. The location of this incident was immediately to the NW of the Willow Ridge plot in the Stonegate community. The perched water table outcrops behind the Diaz home, and flooding problems from that zone coincided with upslope construction (Exhibit 8).

Landslide Risk

The eastern half of the Willow Ridge Development plot is shown on Oregon State Department of Geology and Mineral Industries Shallow Landslide maps as having a moderate to high susceptibility to shallow landslides (Exhibit 9). Activities resulting in increased soil water content or removal of slope-toe materials will increase this risk.

The Oregon Department of Geology and Mineral Industries document “A Homeowner’s Guide to Landslides” is used as a reference for defining landslide types. A landslide refers to any downslope movement of soil, rock, or slope debris. Mudslides, mudflows, debris flows, rock falls, and slumps are all terms describing landslides. The types of landslides of concern in the discussion of Willow Ridge Development risk factors are rockfalls, and slumps.

A rotational slide occurs when a large section of earth is transported downslope by sliding on a discrete detachment surface. The mass of soil and rock will partially disaggregate as it moves downslope. Rotational slides can occur when slopes are too steep or in areas where the base of the slope is undercut by either natural or man-made processes. Any changes to the current Willow Ridge slope that affect the base of the steepest slopes will increase the risk of a rotational slump or rockslide. The controlling factor is removal or destabilization of existing material at the toe of the slope.

The two factors to evaluate for this risk are: planned removal of material during construction, or increased water flow (surface or subsurface) at the base of the slope. The current understanding of the geology is that water is currently exiting the toe of the steepest slope in the form of springs. Any changes above this seep zone that result in increased ground water will cause increased water flow from the existing seeps or the formation of new seeps at the toe of

the slope. This increased flow could destabilize the slope toe and result in increased risk of landslide (Exhibit 10).

Based on the geology of the Reed Street Well the steepest portions of the existing slope are composed of loose, gray/brown basalt. The next zone of gray/brown basalt approximately 20 feet deeper is described as fractured. Loose or fractured basalt indicates a degree of disaggregation in the rock unit. Removal of structural support at the base of this unit on the slope could result in near surface collapse of the overlying unit and disaggregation of the mass into a shallow rockslide.

Mud flows or shallow slumps are the second type of landslide risk. These types of movement are not historically noted on the Willow Ridge Plot or in the properties below the slopes. However, increased ground water on the lower slopes would result in a higher risk with regards to these types of shallow landslide risk, but the degree of increased risk cannot be quantified with the data available and more studies are required.

Comment on the ICON Willow Ridge Development Application

The ICON January 7, 2020 Development Review Application, received January 13, 2020 by the City of West Linn., provides a geotechnical report on the Willow Ridge property. The application notes the potential for perched water aquifers in basalts but does not discuss the risk implications of the proven perched aquifer encountered in the Reed Street Well, nor does it specifically address mitigation of that risk.

The geotechnical report is dated Jan 7, 2016 and thus does not address the public testimony presented in 2017 by Chelsea Diaz. The Stonegate homes are exposed to the same geological and hydrological conditions that exist on the Willow Ridge property. The homes are below the base of the water flow zone just like the Fairhaven homes on the SW edge of the Willow Ridge property. Flooding risk from a new development due to changes in ground water flow is a proven risk that is not specifically discussed in the application, and needs to be addressed to understand what control measures will be considered for mitigating ground water discharge from the perched water table.

The geotechnical report provides a representative review of the near surface geology and the seven test excavation pits show geology similar to the uppermost portion of the Reed Street Well with silts and clays underlain by weathered basalts. These pits excavated up to 10 feet of material, but in general sampled 6 – 8 feet below the ground surface. Three of test pits (TP-4, TP-5, & TP-6) encountered ground water seepage. Two of these pits (TP-5 & TP-6) are located on the lower slope below the perched water table outcrop, and they experienced ground water seepage at about 4 feet BGL, demonstrating lower slope water flow in the soils. This groundwater flow system is not discussed in the application, and no plans are presented for mitigation.

The report notes that the native surface soils on the slope are sensitive to small changes in moisture content and present stability issues for earth work performed during wet weather. The report does not specifically address the potential for shallow landslides due to undercutting slope bases, over steepening existing slopes, or increasing the shallow ground water flow. Given that the Oregon State Department of Geology and Mineral Industries Shallow Landslide maps identify the Willow Ridge property as having moderate to high susceptibility to shallow landslides, plans to mitigate this risk should be part of the planning process.

The report does state that under current conditions the risk of seismically induced slope instability is low. Well planned drainage control to maintain the current ground saturation conditions is part of the process of insuring that current slope stability conditions are maintained. While surface water drainage is discussed in the application, ground water drainage is not, and plans should be in place to mitigate the risk posed by this element of the hydrologic system.

The steepest portions of the Willow Ridge slopes between 467 feet and 481 feet ASL are interpreted to be compose of loose, gray/brown basalt based on the Reed Street Well. The application does not specifically address this zone or measures needed to ensure that, during construction, slope stability will be maintained to prevent shallow rockslides.

William House

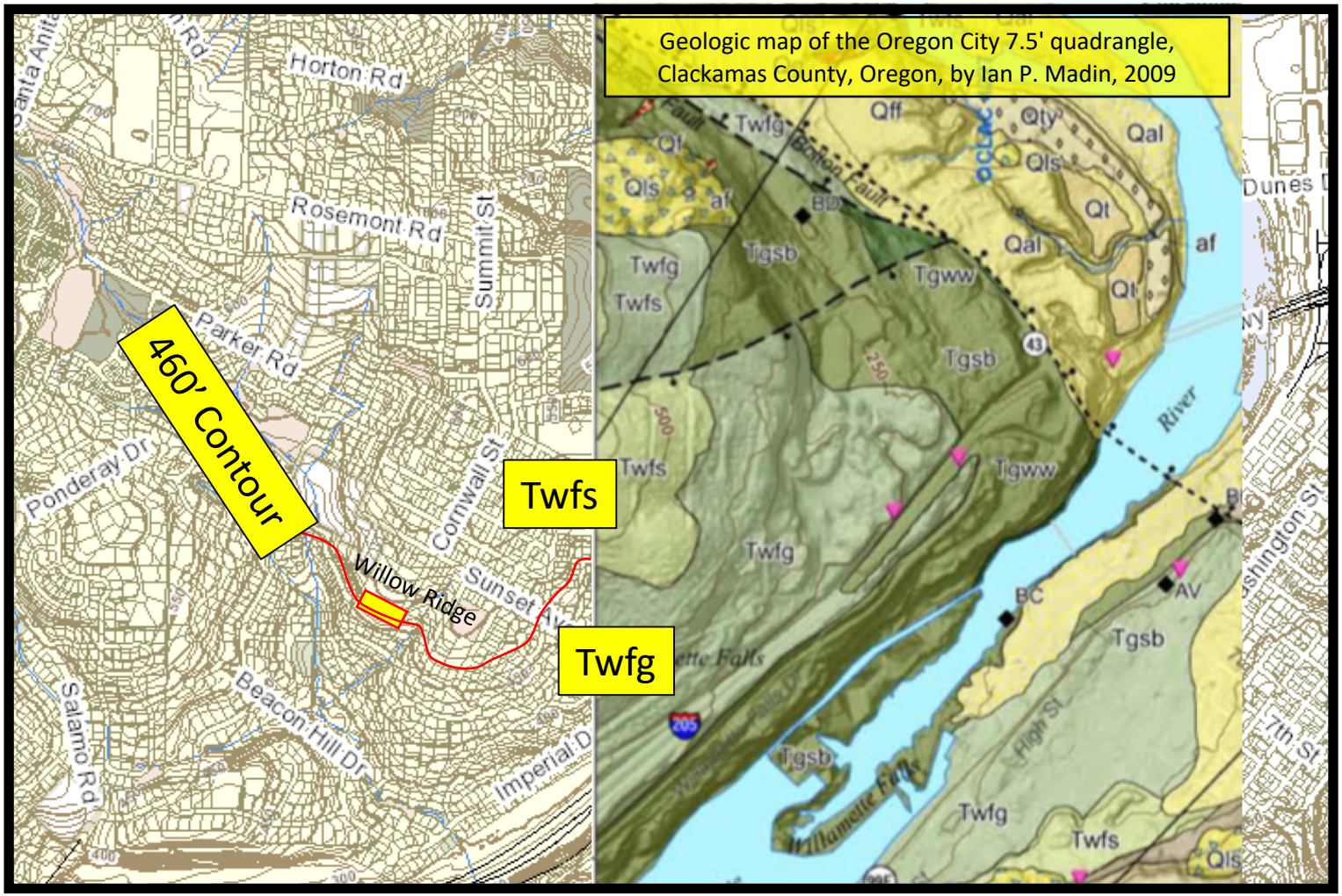
William House is a retired professional geologist with an academic background that includes an MS Degree in Geology and a BA Degree in Environmental Sciences. He has extensive experience in subsurface geology from working as an exploration geologist in the petroleum industry for 34 years.

EXHIBITS

1 Geologic Map
    a. Local Stratigraphy
2 Well Report: Clackamas County water well CLAC 69447
3 Reed Street Well Location Map 1
4 Reed Street Well Location Map 2
5 Reed Street Wellbore Profile
6 Map: Outcrop of Perched Water Flow Zone
7 Geologic Profile Across Willow Ridge Property
    a. Location Map for Geologic Profile
8 Public Testimony: Stonegate Ground Water Drainage Issue
9 Map: Shallow Landslide Risk
10 Schematic of Rock Slide Risk Factors

Exhibit 1

Maps showing the extension of the contact between the Sandy Hollow and Gingko units of the Frenchman Springs member of the Wanapum Basalts



Legend provided in Exhibit 1a

Exhibit 1a

Local Stratigraphy

Miocene Columbia River Basalt Group lavas

Twfs	**Wanapum Basalt, Frenchman Springs Member, basalt of Sand Hollow (Miocene)** — Black medium-grained basalt flows with sparse plagioclase phenocrysts, well developed columnar jointing.
Twfg	**Wanapum Basalt, Frenchman Springs Member, basalt of Gingko (Miocene)** — Black medium-grained basalt flows with abundant plagioclase phenocrysts, well developed columnar jointing.
Tgsb	**Grande Ronde Basalt, Sentinel Bluffs Member (Miocene)** — Sentinel Bluffs Member (middle Miocene) — black fine-grained basalt flows with sparse plagioclase phenocrysts, well developed columnar jointing.
Tgww	**Grande Ronde Formation, basalt of Winter Water (Miocene)** — Flow or flows of fine-grained basalt.

The Columbia River Basalt flows are considered to be generally tabular and undeformed, thus their exposure elevations on the Oregon City Quadrangle geologic map are probably very close to their elevations on Willow Ridge

Exhibit 2

Well Report:

Clackamas County well CLAC-69447

4197 Reed Street

(Reed Street Well)

Retrieved from the Oregon Water Resources Department

STATE OF OREGON
WATER SUPPLY WELL REPORT
(as required by ORS 537.765)
Instructions for completing this report are on the last page of this form

CLAC 69447
SKYLES DRILLING, INC.
503-656-2683

WELL ID # L 110853
START CARD # W208221

(1) OWNER: Well Number: 01
Name Pacific Lifestyle Homes
Address 11875 NE 99th St., Suite 1200
City Vancouver State WA Zip 98682

(2) TYPE OF WORK:
X New Well ☐ Deepening ☐ Alteration (repair/recondition) ☐ Abandonment

(3) DRILL METHOD:
X Rotary Air ☐ Rotary Mud ☐ Cable ☐ Auger
☐ Other

RECEIVED BY OWRD
FEB 26 2013
SALEM, OR

(4) PROPOSED USE:
X Domestic ☐ Community ☐ Industrial ☐ Irrigation
☐ Thermal ☐ Injection ☐ Livestock ☐ Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval ☐ Yes X No Depth of Completed Well 388 ft.
Explosives used ☐ Yes X No Type Amount

HOLE Diameter	From	To	SEAL Material	From	To	Amount sacks or pounds
10	0	78	Cement w/5%	78		
6	78	422	bentonite		18	62 Sacks
			Bentonite	18	0	8 Sacks

How was seal placed: Method ☐ A ☐ B X C ☐ D ☐ E
X Other Poured bentonite
Backfill placed from ft. to ft. Material
Gravel placed from ft. to ft. Size of gravel

(6) CASING/LINER:

	Diameter	From	To	Gauge	Steel	Plastic	Welded	Threaded
Casing:	6	+2	78	.250	X		X	
Liner:	4	68	388	Sch40		X		X

Drive Shoe used ☐ Inside ☐ Outside X None
Final location of shoe(s)

(7) PERFORATIONS/SCREENS:
X Perforations Method Saw
☐ Screens Type Material

From	To	Slot size	Number	Diameter	Tele/pipe size	Casing	Liner
367	387	1/8x3	72				X

(8) WELL TESTS: Minimum testing time is 1 hour
Pump ☐ Bailer X Air ☐ Flowing Artesian

Yield gal/min	Drawdown	Drill stem at	Time
10		387	1 hr.

Temperature of Water 58 Depth Artesian Flow found
Was a water analysis done? ☐ Yes By whom
Did any strata contain water not suitable for intended use? ☐ Too little
☐ Salty ☐ Muddy ☐ Odor X Colored ☐ Other
Depth of strata: 27' to 46'

(9) LOCATION OF WELL by legal description:
County Clackamas Latitude Longitude
Township 2SOUTH N or S. Range 1EAST E or W. of WM.
Section 36BA NE 1/4 NW 1/4
Tax lot 06000 Lot Block Subdivision
Street Address of Well (or nearest address) 4197 Reed St, West
Linn, OR

(10) STATIC WATER LEVEL:
216 ft. below land surface. Date 2/8/2013
Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:
Depth at which water was first found 27'

From	To	Estimated Flow Rate	SWL
27	46	5	21
216	280	8	216
381	384	2	216

(12) WELL LOG:
Ground elevation

Material	From	To	SWL
Clay, brown	0	6	
Basalt, weathered w/clay, brown	6	27	
Basalt, gray & brown loose	27	40	
Basalt, multicolored	40	46	
Basalt, gray	46	60	
Basalt, gray & brown fractured	60	71	
Basalt, gray	71	96	
Basalt, black fractured @times	96	168	
Basalt, gray fractured	168	186	
Basalt, black fractured	186	216	
Basalt, mc fractured & porous	216	219	216
Basalt, black fractured	219	257	216
Basalt, gray & brown fractured	257	265	216
Basalt, black semi-fractured	265	272	
Basalt, gray	272	286	
Basalt, gray & black fract @times	286	381	
Basalt, gray & brown fract&porous	381	384	216
Basalt, gray & black	384	408	
Basalt, gray	408	422	
Void	422		
Cemented up bottom w/ 11sacks cement & bentonite	422	388	

Date started 2/1/2013 Completed 2/8/2013

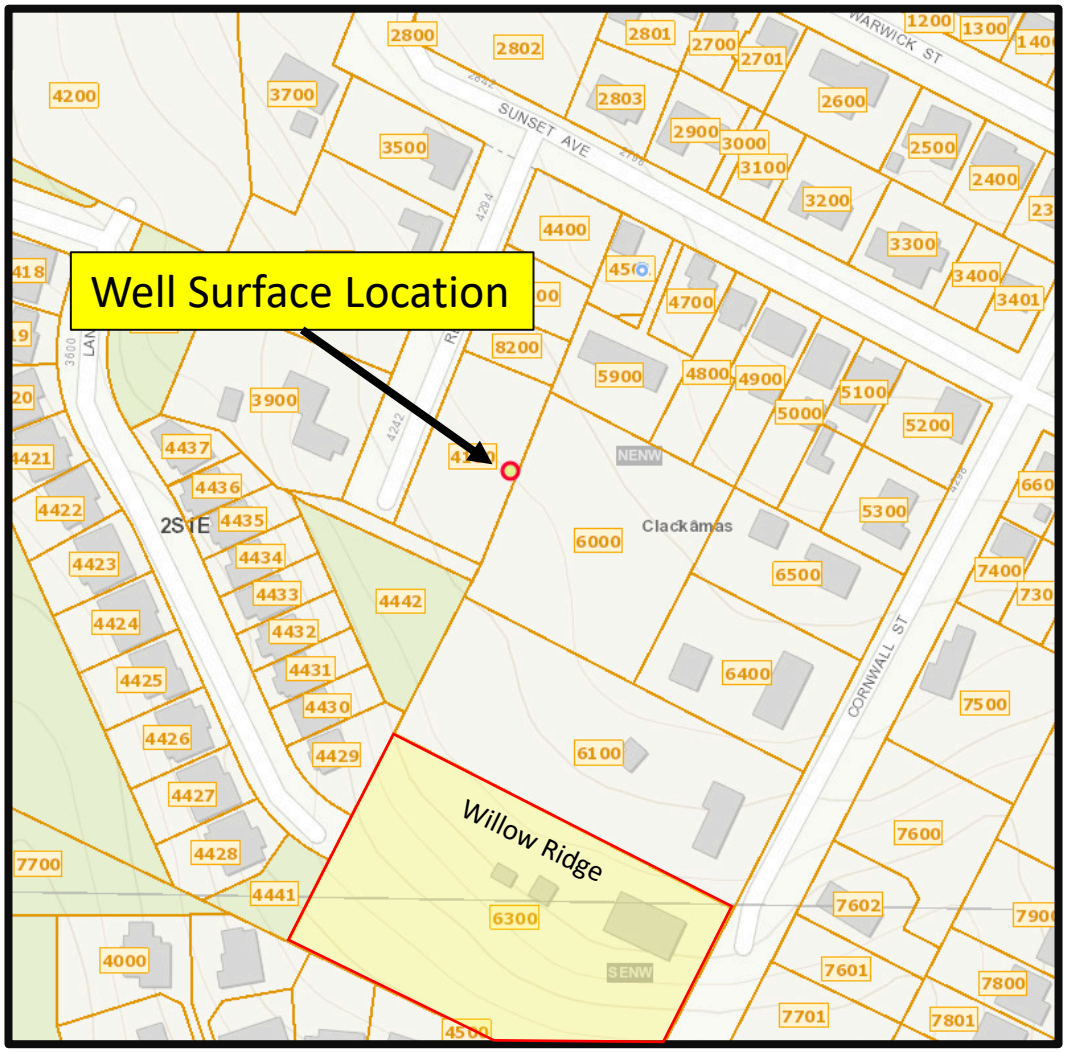
(unbonded) Water Well Constructor Certification:
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.
Signed Skyles Drilling, Inc. WWC Number 1884 Date 2/11/2013

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.
Signed Skyles Drilling, Inc. WWC Number 1592 Date 2/11/2013

ORIGINAL - WATER RESOURCES DEPARTMENT FIRST COPY - CONSTRUCTOR SECOND COPY - CUSTOMER

Reed Street Well Location Map 1

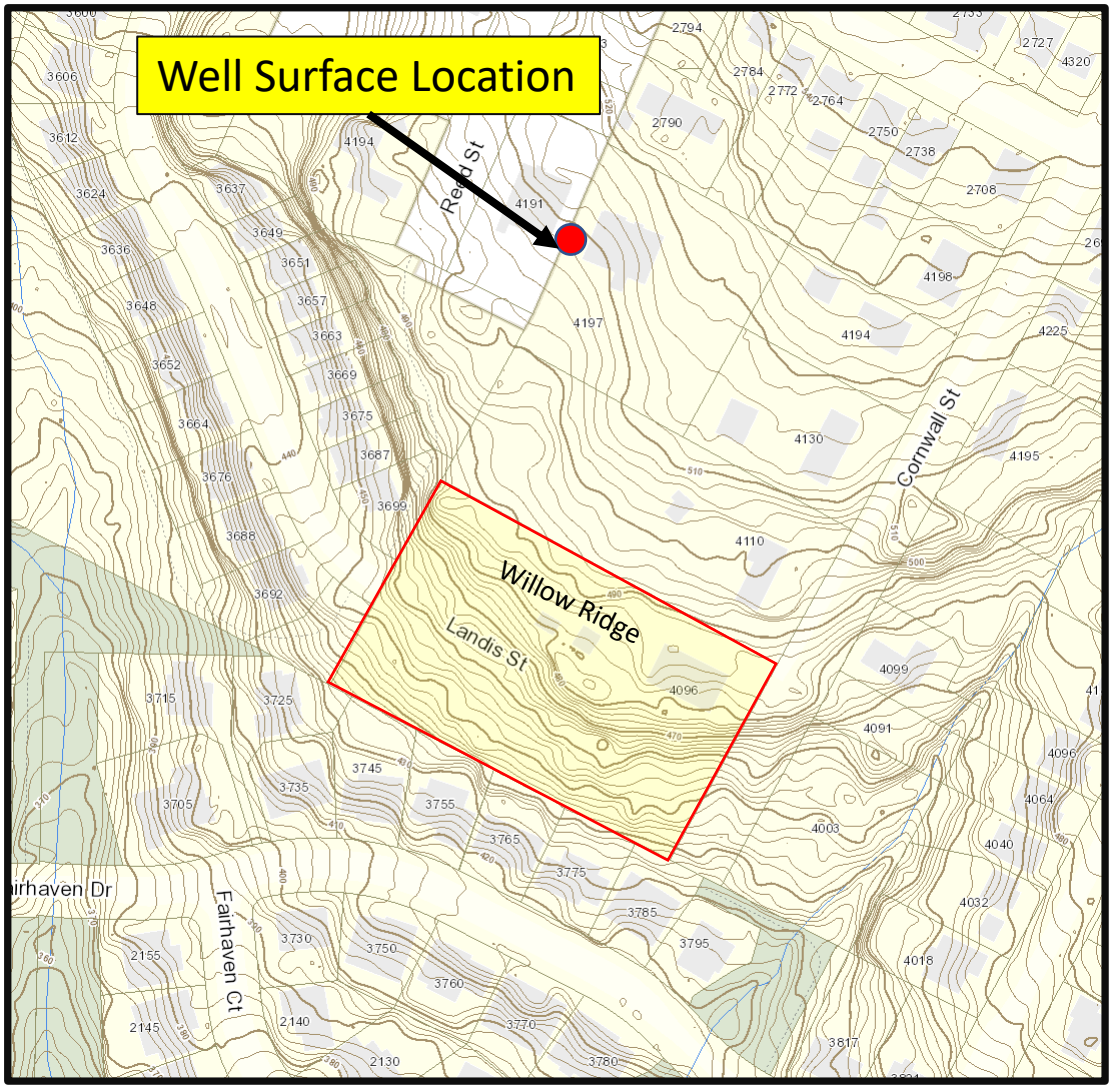
- Type: Water Well
- Completion Date: Feb. 8, 2013
- Company: Skyles Drilling
- TD: 422 ft
- Completion Depth: 388 ft



Oregon Water Resources Department Well Report Mapping Tool

Exhibit 4

Reed Street Well Location Map 2



Surface Elevation approximated at 508 ft. ASL based on maps from the West Linn City Government MapOptix platform using terrain contours from a 2014 topographic survey

Exhibit 5

Wellbore Profile: 4197 Reed Street

Perched water was encountered in this well with a floor at 46 feet below ground level or an elevation of 462 feet asl

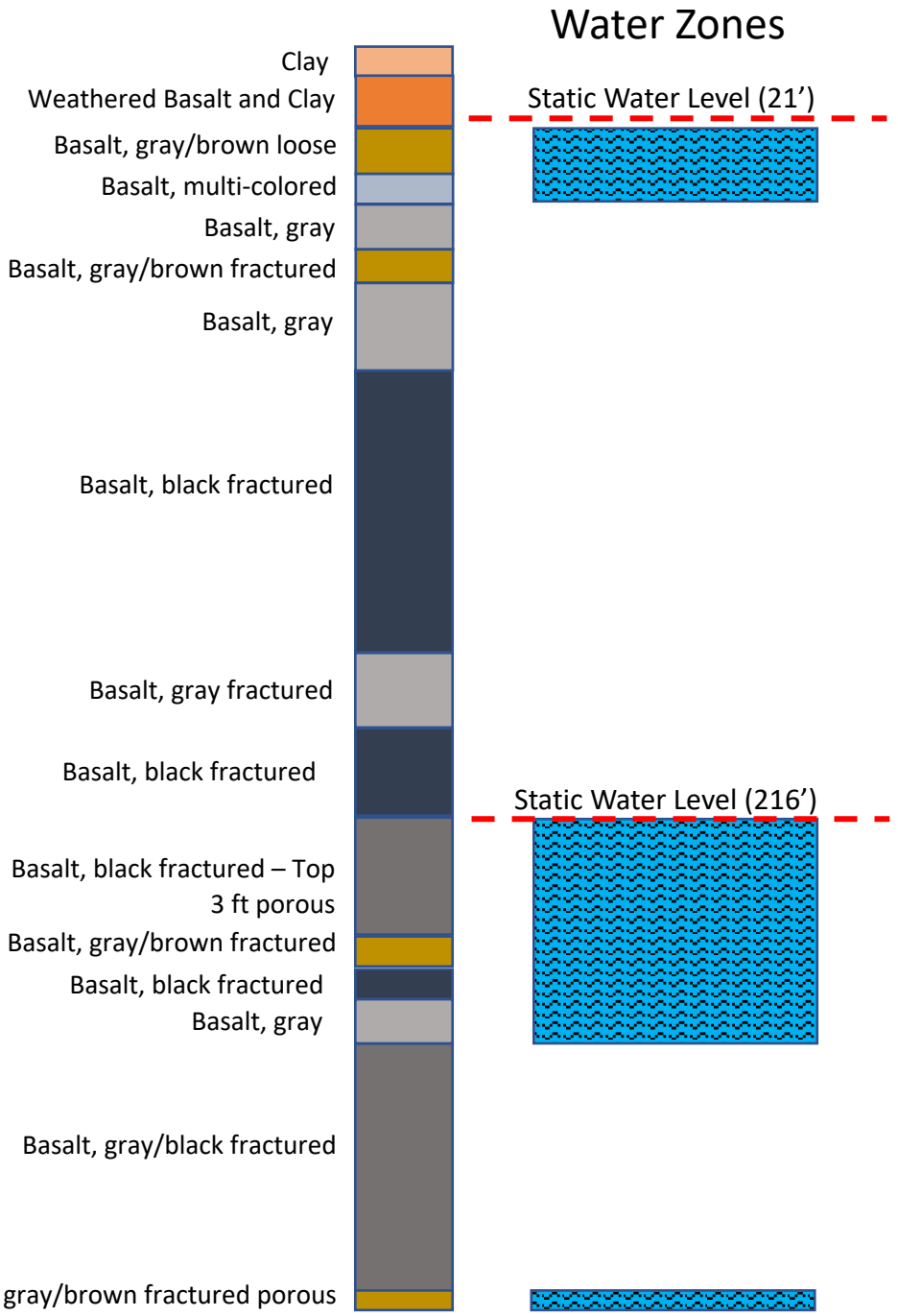


Exhibit 6

Estimated Water Flow Zone based on the Reed Street Well (Uses terrain contours from MapOptix)

Reasons for differences between the ICON map contours and the MapOptix terrain contours are unknown

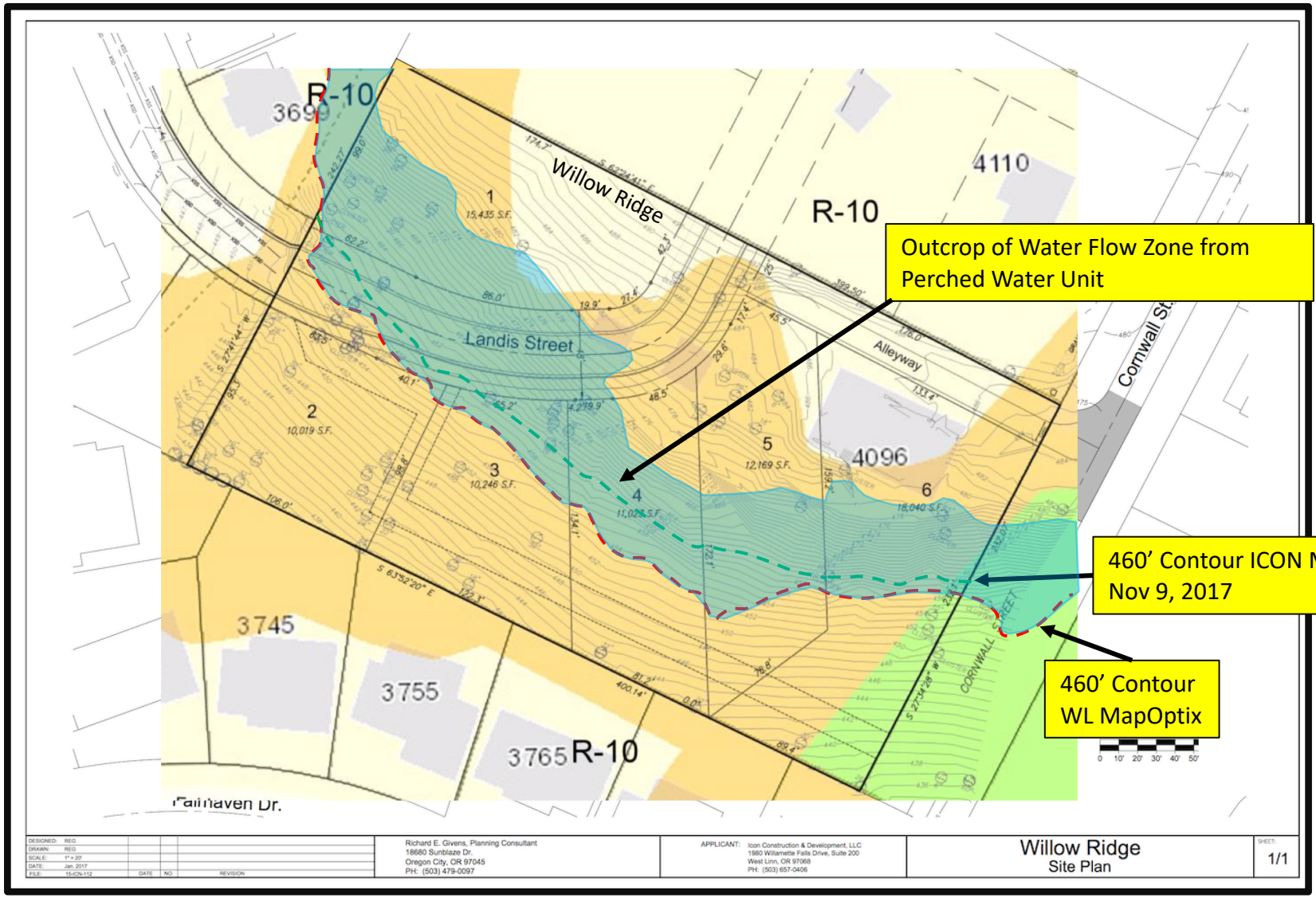


Exhibit 7

Geologic Cross Section (Profile)

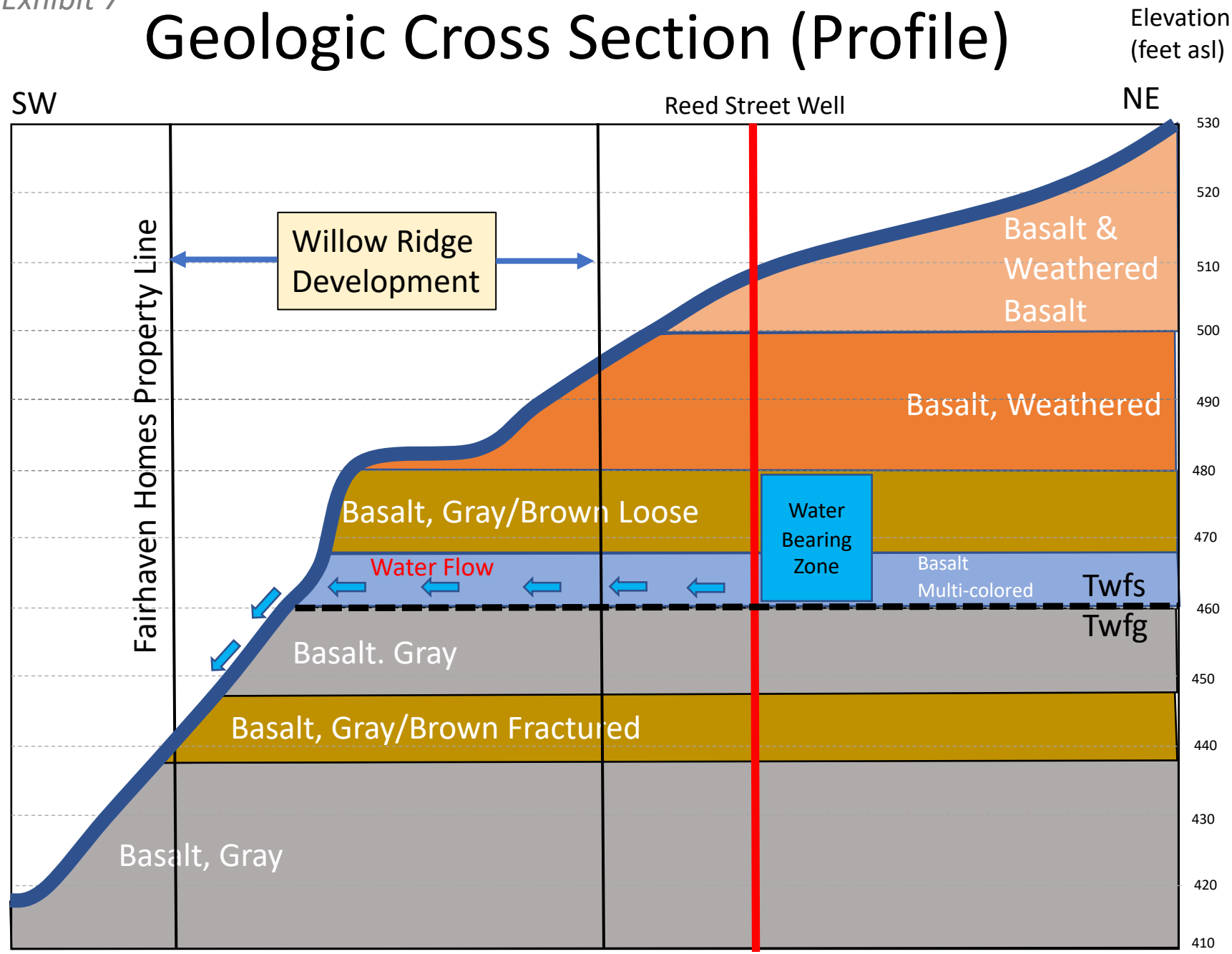
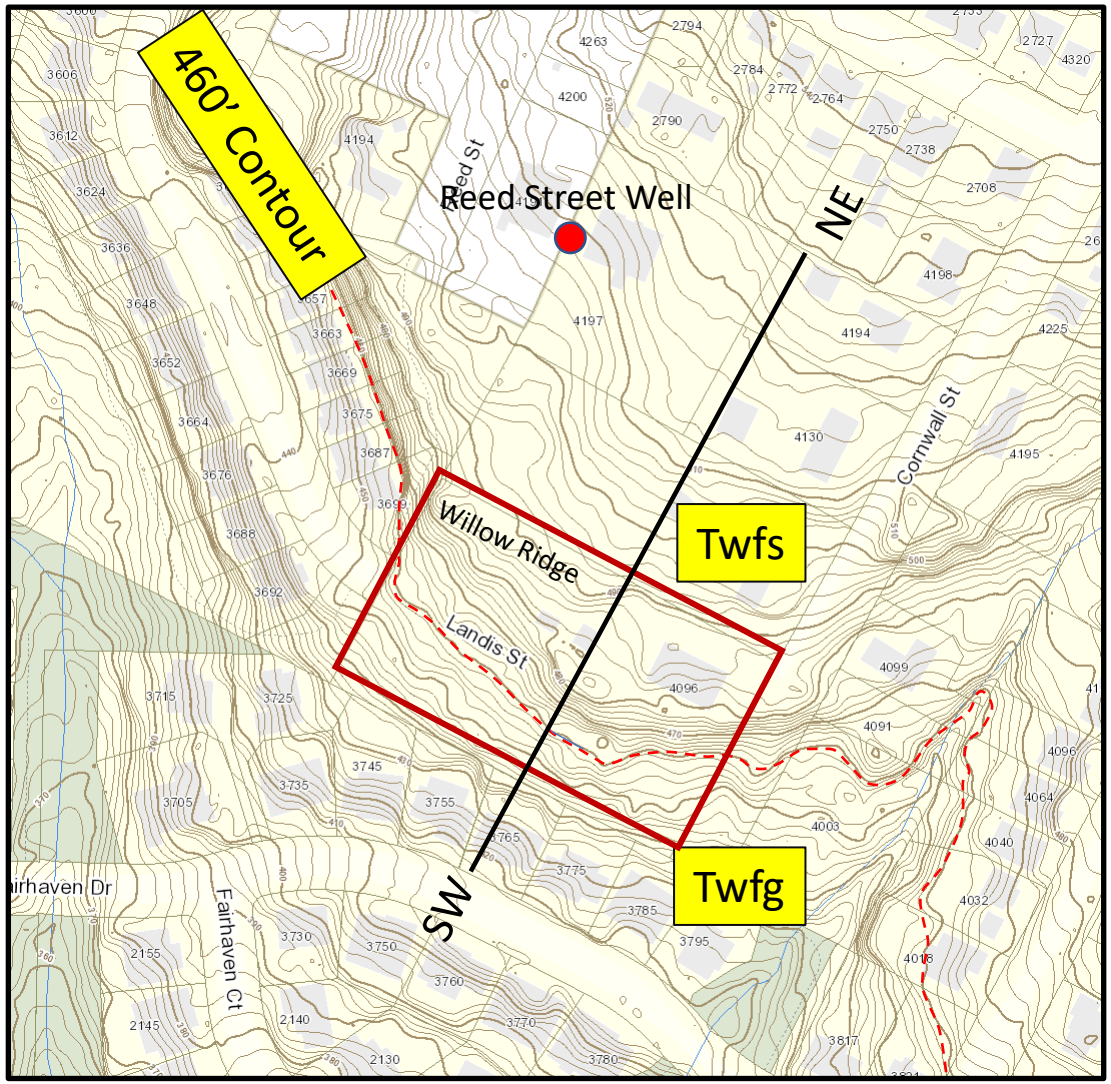


Exhibit 7a

Location map for geologic cross section

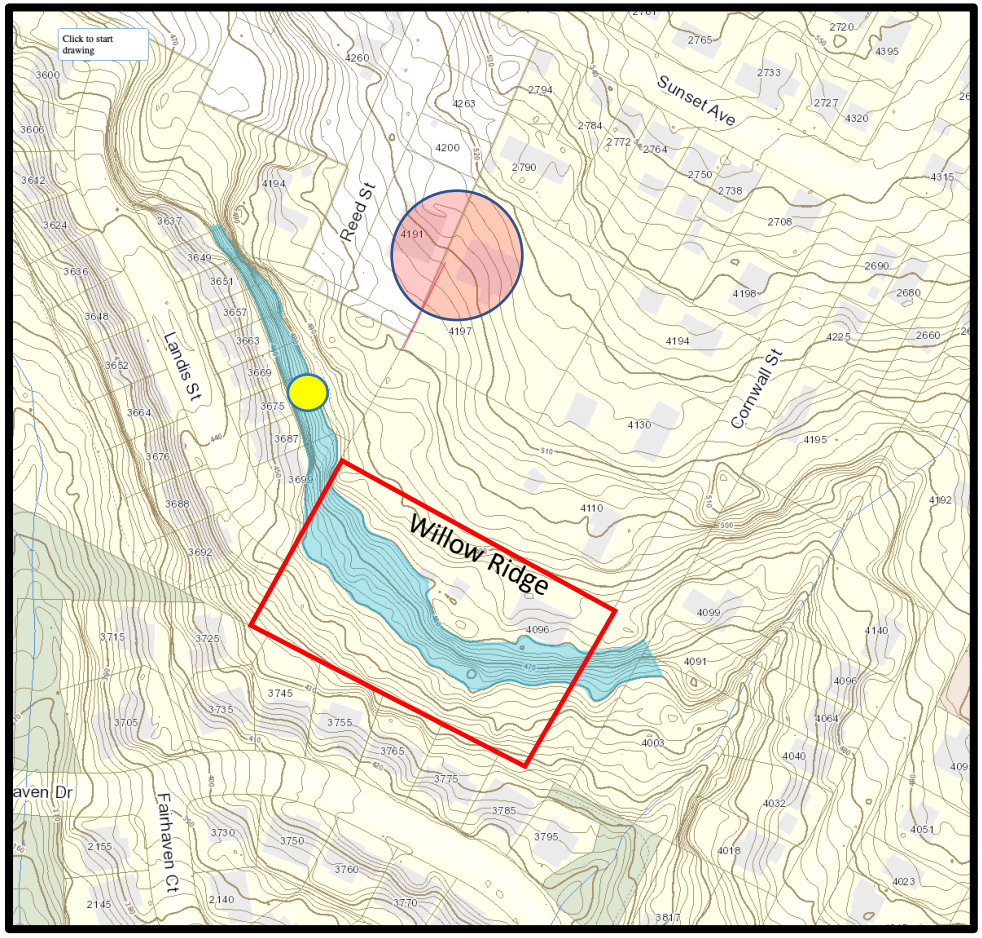


This map shows the location of a geologic cross section that runs in a NE-SW line across the center of the proposed Willow Ridge development.

The Reed Street Well is projected into the cross section based on a ground surface elevation of 508' ASL

Exhibit 8

Public Testimony Dec. 2017:



Chelsea Diaz

"After two homes behind and above us began construction located at 4191 Reed Street and 4197 Reed Street, I noticed water streaming between the boulders in my 25 foot retaining wall into my back yard. I then began an lengthy process of trying to find where the water was coming from. After a landscape developer investigated the issue, he determined that a new spring had formed in the upper tier of my back yard."

This demonstrates the clear connection between construction and changes in drainage above the slope and increased water flow through the "water flow zone" marked in blue.

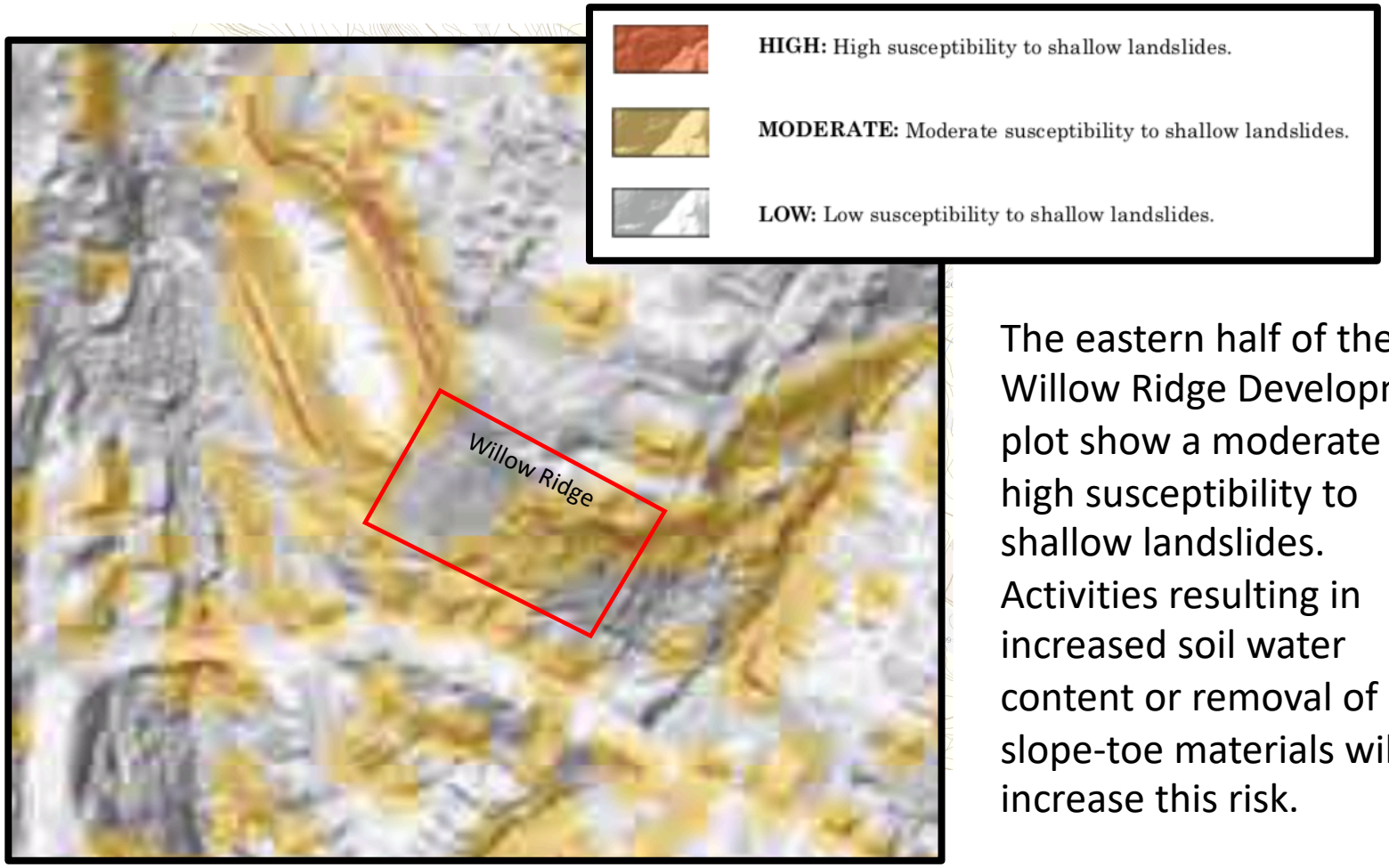
New construction

New spring location

Outcrop of water flow zone

Exhibit 9

Shallow Landslide Risk – Oregon State Department of Geology and Mineral Industries



The eastern half of the Willow Ridge Development plot show a moderate to high susceptibility to shallow landslides. Activities resulting in increased soil water content or removal of slope-toe materials will increase this risk.

Exhibit 10

Rock Fall Risk